Attorney's Docket No.: 10200-005001

APPLICATION

FOR

UNITED STATES LETTERS PATENT

TITLE: LOOP TEST APPARATUS AND METHOD

APPLICANT: DAVID J. LUNEAU

CERTIFICATE OF MAILING BY EXPRESS MAIL

Express Mail Label No. EL010097233US

I hereby certify under 37 CFR §1.10 that this correspondence is being deposited with the United States Postal Service as Express Mail Post Office to Addressee with sufficient postage on the date indicated below and is addressed to the Commissioner for Patents, Washington, D.C. 20231.

February 25, 2002
Date of Deposit

Signature

Leroy Jenkins
Typed or Printed Name of Person Signing Certificate

This application claims priority from U.S. Provisional Patent Application No. 60/271,556, filed February 26, 2001.

TECHNICAL FIELD

The invention relates to systems and methods for measuring the quality of telephone transmission lines. The systems and methods may be used in conjunction with a loop test apparatus that can terminate a telephone line at the customer premises based on a message sent by a centrally located loop testing server (LTS).

BACKGROUND

Changes in the North American telephone network have opened the door to new services available to business and residential customers. In particular, Digital Subscriber Line (DSL) offers customers high-speed data communications and basic telephone service using the existing subscriber line. DSL is compatible with existing analog telephone devices for providing plain old telephone service (POTS). DSL supports a high-speed data channel above the 4 KHz band traditionally used for POTS.

However, characteristics in the local loop can degrade the suitability of the channel for data transmission. Analog telephone lines exhibit a wide range of frequency-response characteristics dependant on a number of factors, including distance from the central office, quality of splices, customer premises wiring, line loading, and customer premises equipment.

There is often no way to determine if a telephone line is suitable to provide DSL service without dispatching a telephone company field technician with a bucket truck to test the line at the customer site. The technician analyzes the customer's local loop, including the premises wiring, using a telephone line test set. The test set gets plugged into a telephone jack at the customer premises, and performs a return loss measurement at various frequencies from 0 to 1.1 MHz, normally spaced apart by 4.3 KHz. The test shows the line's frequency response, and can be used for measuring the quality of the line and identifying problems in the telephone company loop plant or customer premises wiring.

The same technique can also be used to diagnose other problems related to frequency response, including slow modem connections, caller ID failure, and sometimes even poor voice quality.

Other test sets may be operated by telephone company technicians located at the customer premises in order to test the quality of the telephone line back to the central office. It is done this way primarily because a clear analog channel is not set up unless a device at the customer premises is off-hook.

SUMMARY

The present invention concerns telephone line diagnostic equipment and methods. The equipment can include a data detector, a telephone line terminator, and a processor. The data detector and telephone line terminator are both configured to be connected to a telephone line (such as by a standard RJ-11 telephone jack). The data detector detects data provided on the telephone line, provides signals representing the detected data to a processor (such as a computer microprocessor). The telephone line terminator terminates the telephone line in response to a termination signal received from the processor. The processor generates such a termination signal when it detects a Loop Test Message from the data detector.

The apparatus can be installed at the customer premises as a stand-alone unit or integrated into common POTS CPE (e.g., telephone, modem, answering machine, Caller-ID box). The apparatus goes off-hook in response to a Loop Test Message sent by, e.g., a LTS located, e.g., at the Central Office (CO), thereby causing the line to go off-hook at the customer premises to create a complete analog transmission path between the LTS and the customer premises. While the telephone line at the customer premises is off-hook, the LTS can then send test signals (e.g., signals at a range of frequencies) on the telephone line, and receive signals reflected back on the telephone line from the customer premises, e.g. to perform a return loss measurement to determine aspects of the frequency response of the telephone line. The apparatus thus avoids the need to dispatch telephone company service resources to the customer premises.

Embodiments of the invention can include the following features. The data detector is a frequency-shift key (FSK) detector, and the data detected by the data detector on the telephone line is encoded in accordance with the GR-30 standard. The telephone line terminator includes a

resistor and a relay configured to terminate the telephone line with the resistor when the relay is energized by the termination signal. The processor monitors the duration of the termination signal, and ends the termination signal to cause the line to go on-hook if the duration of the termination signal exceeds a predetermined length of time (e.g., 10 seconds).

The apparatus can also include a voltage detector configured for connection to the telephone line. The voltage detector detects the voltage level the telephone line and to provide signals representing the voltage level to the processor. The processor ends the termination signal to cause the line to go on-hook if a signal representing an open switching interval is detected by the voltage detector, or if the voltage detector detects an extension telephone device going off-hook (e.g., where the voltage level drops by more than 5% or 500mV, whichever is greater). The apparatus can also include a dual tone multi-frequency (DTMF) controlled by the processor, and if an extension telephone device is detected going off-hook, the processor can cause the DTMF generator to provide DTMF signals on the telephone line, e.g., to signal back to the LTS that the test has been interrupted.

Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. Although methods and materials similar or equivalent to those described herein can be used in the practice or testing of the present invention, suitable methods and materials are described below. All publications, patent applications, patents, and other references mentioned herein are incorporated by reference in their entirety. In case of conflict, the present specification, including definitions, will control. In addition, the materials, methods, and examples are illustrative only and not intended to be limiting.

The details of one or more embodiments of the invention are set forth in the accompanying drawings and the description below. Other features, objects, and advantages of the invention will be apparent from the description and drawings, and from the claims.

DESCRIPTION OF DRAWINGS

Figure 1 is a block diagram of a loop test apparatus.

Figure 2 is a flow chart of the processing states of the loop test apparatus shown in Figure 1.

Figure 3 is a diagram illustrating the interaction between the loop test apparatus, a loop test server, and a telephone line.

DETAILED DESCRIPTION

A block diagram of a loop test apparatus 10 in accordance with the invention is shown in Figure 1. The loop test apparatus 10 is connected to the telephone network at connection point 12, typically an RJ-11 "modular" telephone jack common to most telephones. The loop test apparatus 10 includes several functional circuits, including Ring Voltage detector 14, frequency-shift keyed (FSK) detector 16, Line Voltage detector 18, dual tone multi-frequency (DTMF) transmitter 20, and Hook Switch relay 22, that are all controlled by software running on Microprocessor 26.

Ring Voltage detector 14 detects the presence of ring signals transmitted by the telephone company switching system. Ring Voltage detector 14 is an optoisolator circuit, such as Siemens part 4N26, bridging to the line through a high voltage capacitor and resistor so as to minimize ringer loading. The output of detector 14 indicates the presence of ring signals on the line, and is connected to Microprocessor 26.

FSK detector 16 receives frequency-shift keyed data present on the telephone line, converts the data into a digital format, and sends the digital data to Microprocessor 26 in the form of a serial data stream. FSK detector 16 is a caller ID data receiver chip incorporating filtering and frequency control, such as Mitel part MT8841. FSK detector 16 bridges the telephone line using a pair of high voltage capacitors and resistors (not shown).

Line Voltage detector 18 monitors the telephone line voltage. Line Voltage detector 18 is an analog-to-digital converter, such as from Analog Devices. Line Voltage detector 18 is programmed to detect voltages in the range of 0-21V with resolution of 500mV.

DTMF Transmitter 20 is used by Microprocessor 26 to transmit DTMF signals on the telephone line. DTMF Transmitter 20 is a digital-to-analog converter implemented using an operational amplifier, such as National part LM324, driven by outputs from Microprocessor 26 carrying linear pulse code modulated (PCM) data representing the waveform of the DTMF signal.

Hook Switch relay 22 is used to apply termination resistor 24 across the telephone line, causing the apparatus to become off-hook. Relay 22 is controlled by a signal from Microprocessor 26, and is typically a single-pole single-throw form of relay, available from companies such as Omrom.

Termination resistor 24, when connected across the telephone line by relay 22, is sufficient to draw current through the telephone loop, causing the telephone company switching system to detect an off-hook condition. Termination resistor 24 is 600 ohms.

The loop test apparatus 10 is located at the customer premises and can be used for remotely diagnosing telephone line impairments, especially concerning the local loop and customer premises wiring, e.g., for determining if the line is suitable for new services, such as DSL. In general terms, the loop test apparatus 10 incorporates an integrated local loopback feature that can be controlled from a remote LTS. The loop test apparatus 10 reflects signals transmitted by the LTS back to the LTS so that line characteristics present in the local loop and customer premises wiring can be analyzed.

In operation to evaluate the characteristics of the telephone line, the LTS accesses the loop test apparatus 10 through a stored program controlled switch (SPCS) located in the telephone company Central Office (CO). After the SPCS establishes a voice path to the customer premises in question, the LTS transmits an on-hook GR-30-encoded message to the loop test apparatus 10. In some cases, it may be necessary for the SPCS to transmit an abbreviated ring, ping ring, or open switching interval (OSI) in order to establish the voice path. GR-30 (Bellcore GR-30-CORE, Voiceband Data Transmission Requirements "GR-30") is an open standard that historically has been used for sending Caller ID (ICLID) information to telephone customers, an enhanced subscriber service offered by local telephone companies for a nominal monthly charge. No special provisions are necessary at the telephone company central office switching system other than for Bellcore-standard GR-30 message types, which is now provided by generic software packages from all major switching system manufacturers.

The GR30-encoded message is a Loop Test Message defined specifically for purposes of remotely activating the loop test apparatus 10 at the customer premises, and contains message content that directs the apparatus 10 to go off-hook, as well as optional content relating to the time of day the test is performed and duration of the test.

Figure 2 is a flowchart illustrating the processes used to implement the loop test feature. Processing begins at step 100 when the device is enabled. Step 110 checks FSK detector 16 for incoming messages. If a Loop Test Message is received at step 110, processing continues to step 111, where processing waits for a "random" amount of time in the range of 0-1000ms. The "random" time is derived from a counter running on Microprocessor 26, beginning with the application of power, and develops a random value over time as a result of variation in microprocessor timing crystals and through "random" events such as user access and ring signal detection. (Variations in components used for clocking the internal micro-controllers should, after a very short period of time, allow for good random value generation. In addition, "randomness" can be improved by allowing "random" events such as key presses and ring signals to effect the state of the random variable.)

Following the random wait in step 111, step 112 checks the state of Voltage Detector 18 to see if an extension telephone device is off-hook. If the line voltage is less than 21 VDC, the line is considered to be in-use by another extension (i.e., off-hook). If an extension device is off-hook, then processing continues to step 122 to transmit a disconnect signal to the LTS using DTMF generator 20, then on to step 120, thereby releasing any termination applied to the line by Hook Switch relay 22. If no extension devices are found to be off-hook (i.e., if the line voltage is at least 21 VDC, then processing continues to step 114.

Step 114 engages Hook Switch relay 22, applying line termination resistor 24 across the telephone line, and therefore causing the device to go off-hook and the telephone line to become "in-use." This action is used to "complete" the call, through the telephone network switching equipment, back to the LTS.

Step 116 measures how long Hook Switch relay 22 is engaged. If relay 22 is engaged for more than 10 seconds, processing continues to step 120, whereby relay 22 is released, returning the device on-hook. If relay 22 has been engaged for less than 10 seconds, processing continues at step 118.

Step 118 monitors Voltage Detector 18 for a sudden drop in voltage, known as an open switching interval (OSI), indicating the LTS has stopped the test and released the line. While off-hook, if the apparatus detects a 500ms OSI, processing continues to step 120, whereby relay

22 is released, returning the device on-hook within 100ms. If an OSI is not detected, processing returns to step 112.

While the loop test is in process, the loop test apparatus 10 monitors for any extension telephone sets (or other extension devices) going off-hook. The apparatus 10 detects when an extension set goes off-hook when the "in use" DC voltage drops by more than 5% or 500mV, whichever is greater. If an extension set goes off-hook during the test, the apparatus 10 transmits a DTMF-D signal for 70ms, and go on-hook within 100ms of detecting the voltage drop.

The apparatus has a user-selectable option to disable the loop test feature on the specific device. The apparatus is configured with the loop test feature enabled (as a default).

Other embodiments are within the scope of the following claims.